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NASA TECH BRIEF

Lewis Research Center

Advanced Fiber-Composite Hybrids -- A New Structural Material

The Problem:

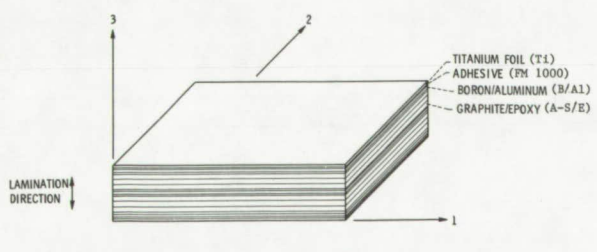
Advanced fiber/resin and fiber/metal matrix composites are used most efficiently when the fiber and load directions are coincident. To provide strength or stiffness in more than one direction, composites with fibers oriented in several directions are necessary. Orienting fibers in more than one direction in the same composite, however, increases the fabrication complexities, reduces their efficiency, and can introduce lamination residual stresses comparable to the transverse and shear strength properties of the unidirectional composite. These lamination residual stresses may limit the resistance of the composite components to mechanical loads. In particular, it may reduce their resistance to thermal and/or mechanical cyclic load. In addition, commercially available graphite-fiber/resin and boron-fiber/aluminum composites are inherently weak in impact and erosion resistance.

The Solution:

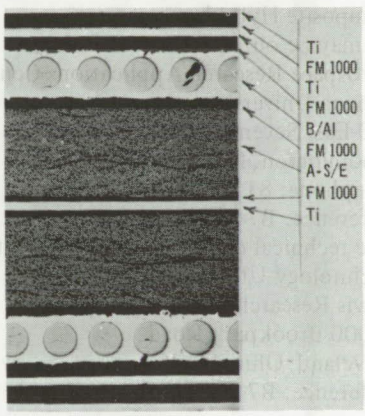
Introduction of a metal foil as part of a matrix and fiber composite, or "sandwich," improves strength and stiffness for multidirectional loading, improves resistance to cyclic loading, and improves impact and erosion resistance of resultant fiber-composite hybrid structure.

How It's Done:

Unidirectional fiber composites made from graphite-fiber/epoxy and boron-fiber/aluminum and a few strategically located titanium foil layers were adhesively bonded to form the metal and resin matrix fiber composite hybrid (see sketch).



A - Schematic of adhesively-bonded metal matrix and resin matrix fiber composite hybrid.



Type V, Ti/(B/Al)/(A-S/E).

B - Photomicrographs of composite specimen cross sections. Magnification, 50X.

Laminates were made using various combinations of the above composite systems. Specimens from these laminates were subjected to tensile, flexure, Izod impact, and notch-sensitivity tests. Laminate analysis was used to calculate the lamination residual stresses throughout the hybrids. The results obtained were compared with those of unidirectional materials with respect to impact resistance, notch-sensitivity, transverse strength, and ease of fabrication.

Mechanical tests of adhesively-bonded composite hybrids showed that it is possible to make a composite with the following desirable properties:

1. Longitudinal strength and stiffness approaching corresponding properties of other advanced fiber composites;
2. Transverse flexural strength approaching that of the yield strength of titanium alloy, TI-6A1-4V;
3. Longitudinal impact resistance approaching that of aluminum;
4. Transverse and shear stiffnesses comparable to those of 6061 aluminum; and
5. Density comparable to that of commercially-available E-glass/epoxy composites.

(continued overleaf)

Notes:

1. The lamination residual stresses in the adhesive are about 50 percent of its corresponding failure stresses, therefore, capacity remains in the hybrid composites for carrying mechanical load.
2. Judicious location of the titanium-foil layers in the laminates may result in predictable high energy absorption failure modes for these hybrids.
3. These types of hybrids may be designed to have inherent fail safe characteristics.
4. These types of hybrids should be of interest to designers and fabricators of structural components designed to meet a multitude of strength and environment requirements.
5. Further information is available in the following report:

   NASA TM-X-71580 (N74-30002), Boron/Aluminum-Graphite/Resin Advanced Fiber Composite Hybrids

   Copies may be obtained at cost from:

   Aerospace Research Applications Center
   Indiana University
   400 East Seventh Street
   Bloomington, Indiana 47401
   Telephone: 812-337-7833
   Reference: B74-10247
6. Specific technical questions may be directed to:

   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B74-10247

Patent Status:

Inquiries concerning rights for the commercial use of this invention should be addressed to:

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